



## Article

# Small mammals from Mondeval de Sora (San Vito di Cadore, Belluno): paleoenvironmental differences between early and late Holocene

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## Key words

- small mammals
- paleoenvironment
- Holocene
- Mondeval de Sora
- North-Eastern Italy

## Parole chiave

- micromammiferi
- paleoambiente
- Olocene
- Mondeval de Sora
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## Summary

Small mammal fossil remains from Mondeval de Sora (VF1, sectors I and III) have been analyzed in order to allow a reconstruction of the environment surrounding the site throughout the Holocene. A taxonomic study has led to the identification of 14 species while statistics tools as Simpson index and Habitat Weighting method have been applied to examine the assemblage from a biological and ecological perspective. Sector I has yielded a very low number of remains (total N.I. 24) whereas sector III has proved to be richer (total N.I. 148), allowing to observe landscape changes through the sequence between early and late Holocene. In particular, variations in the associations of small mammals indicate a shift from a mainly grassland environment during the early Holocene (Mesolithic macro-unit) to a less grass-covered one with exposed rocks during the late Holocene (Protohistoric and Historic macro-units). Furthermore, the occurrence of *Sciurus vulgaris* testifies the presence of wooded areas near the site, suggesting a tree limit probably located at a higher altitude than the current one.

## Riassunto

I resti fossili di micromammiferi provenienti da Mondeval de Sora (VF1, settore I e III) sono stati studiati allo scopo di ottenere una ricostruzione dell'ambiente nelle immediate vicinanze del sito durante l'Olocene. Lo studio tassonomico ha portato all'identificazione di 14 specie, mentre strumenti statistici come l'indice di Simpson e il metodo dell'Habitat Weighting sono stati impiegati per esaminare l'insieme faunistico dal punto di vista biologico ed ecologico. Il settore I ha restituito un basso numero di resti (N.I. totale 24), mentre il settore III si è dimostrato più ricco (N.I. totale 148) permettendo di osservare attraverso la sequenza i cambiamenti ambientali avvenuti tra l'inizio e la fine dell'Olocene. In particolare, le variazioni nell'associazione di micromammiferi indicano il passaggio da un ambiente prativo con buona copertura del terreno durante l'inizio dell'Olocene (macro-unità mesolitica) ad uno con scarsa copertura e rocce esposte durante la fine dell'Olocene (macro-unità protostorica e storica). Inoltre, la presenza di *Sciurus vulgaris* testimonia la vicinanza al sito di aree boschive, suggerendo un limite degli alberi probabilmente ad altitudine più elevata rispetto all'attuale.

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Fig. 1 - Localization of Mondeval de Sora. The site is clearly above the present tree limit. / Localizzazione di Mondeval de Sora. Il sito si trova chiaramente al di sopra dell'attuale limite degli alberi

## The site

The Mondeval de Sora terrace is located in the high valley of the Cordevole River, a sub-tributary of Piave River. The site, also known as Val Fiorentina 1 (VF1), is located at 2.150 m a.s.l. (Fig. 1) and lies beneath two shelters of a big erratic boulder in an area surrounded by high elevations and connected to other valleys by large passes (i.e. Passo Giau) and narrow saddles (i.e. Forcella Ambrizzola) (Fontana et al. 2009).

Two sides of the boulder have been investigated from the 1980s to the 2001 (known as sectors I and III). At the base of the two sequences, several Mesolithic layers are present (Sauveterrian and Castelnavian) which are covered by strata that testify human occupation from the Copper age to the sub-actual age (Alciati et al. 1994; Fontana & Guerreschi, 2003; Asolati et al. 2005; Fontana et al. 2009a, b, 2012).

## Materials and methods

The small mammals remains analysed consisted of disarticulated bone fragments collected by water-screening using sieves of 1 mm mesh during the excavation campaigns.

The sample coming from the two sectors have been analyzed with a stereo-microscope at 25x magnification. The taxonomic classification follows Wilson and Reeder (2005) except for *Clethrionomys glareolus* which priority has been discussed in Tesakov et al. (2010). Data on the distribution and habitat of the species are in accordance with Amori et al. (2008), Boitani et al. (2003), Mitchell-Jones et al. (1999). The sample has been previously treated with a 1/10 solution of H<sub>2</sub>O<sub>2</sub> and H<sub>2</sub>O.

The Number of Individuals (N.I., the calculation is based on Stratigraphical Units) has been quantified taking into account the most represented anatomical element, both right and left (Berto & Rubinato 2013). In order to reconstruct the palaeodiversity we have used the Simpson index of Evenness

$$(1) \quad 1 - \sum(p_i^2)$$

where  $p_i$  is the proportion of individuals in the  $i^{\text{th}}$  species (Harper 2005; Magurran 2004). The evenness index is constrained between 0 and 1. The index has been calculated using PAST 3.04 avoiding redundant determinations. The habitat percentages have been calculated using the Habitat Weighting method (Evans et al. 1981; Andrews 2006; López-García et al. 2010).

28 Stratigraphic Units of sector III have been grouped into three macro-units (Table 1) following Valletta (2012): the Mesolithic mac-

ro-unit, corresponding to the early Holocene (Preboreal and Boreal) and the Protohistoric and Historic macro-units related to the late Holocene (Subboreal and Subatlantic).

## Results

The total number of individuals calculated for sector I is too low to allow any consideration (N.I. = 24), while sector III has delivered a higher number of remains (N.I. = 148, see Table 2). The dominant taxon in the Mesolithic macro-unit of Sector III is *Microtus arvalis* while in the Protohistoric and Historic macro-units *Microtus (Terricola) ex gr. multiplex-subterraneus* dominates the assemblage (Fig. 2). From the bottom to the top of the sequence *Chionomys nivalis* increases and biodiversity seems to raise (as shown by Simpson index, Fig. 3), due to the occurrence of species like *Talpa caeca*, *Talpa europaea* and *Dryomys nitedula*.

## Discussion

Small mammal fossil assemblages are usually the result of accumulations of pellets as a consequence of hunting activities of nocturnal birds of prey (Andrews 1990), that are normally opportunistic predators and often have a limited range of action (2-3 km distance from the perch). For this reasons they are considered reliable proxy for environmental and climatic changes.

Mondeval de Sora provides a very peculiar context to small mammal studies because of its high altitude (2150 m a.s.l.). Plan de Frea Site 4, located at 1.930 m a.s.l. (Angelucci et al. 1999) and 30 km far from Mondeval de Sora is the only site that provides a comparison for the Mesolithic layers. In this locality, the biodiversity of the small mammal fauna is higher, while the most common rodent is *Clethrionomys glareolus*. *Sciurus vulgaris* is signaled too, although in an open environment context.

Therefore, the Mondeval de Sora faunal assemblage more likely reflects local variations than the general climatic changes of the Holocene. Looking at the whole sequence, the shift from *Microtus arvalis* to *Microtus (Terricola) ex gr. multiplex-subterraneus* as a dominant species, the decrease of species adapted to forest habitats and the increase of the rocky component from the Mesolithic to the Proto- and Historic macro-units are remarkable. They testify a change in the area near the site from a grass-dominated landscape during the early Holocene to a less grass-covered environment characterized by exposed rocks during the Subboreal and Subatlantic and very similar to the present one (Fig. 3). The increase of Open Humid environment in Proto- and Historic macro-units can be related to an increase of precipitation during the colder months, while the increase of Rocky environments can be explained with the decrease of forest-related environment. Also, the relatively high percentage of the forest component in the early Holocene unit (up to 10%, given by the occurrence of *Apodemus (Sylvemus)*, *Clethrionomys glareolus*, and especially of *Sciurus vulgaris*) testifies the presence of wooded areas in the vicinity of the site (approximately a 2 km radius), at about 2000 m a.s.l.

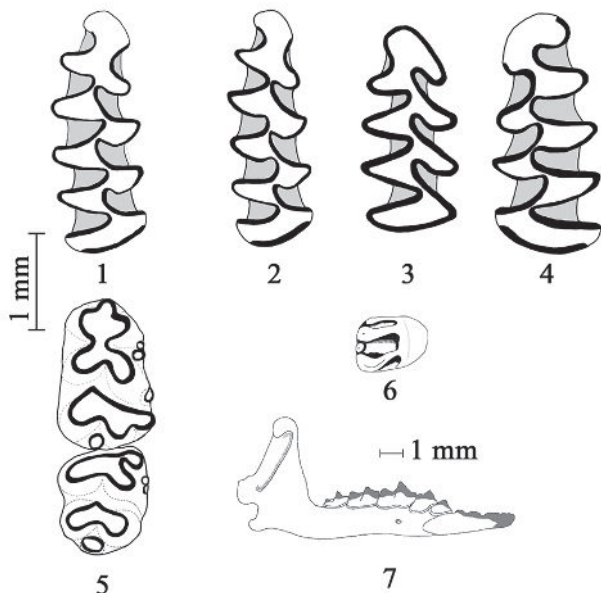
Finally, the increase of Simpson index (Fig. 3) might be pruned

Tab. 1 - Correspondences between macro-units and Stratigraphical Units (data from Valletta 2012) / Raggruppamento delle Unità Stratigrafiche in macro-unità (dati da Valletta 2012)

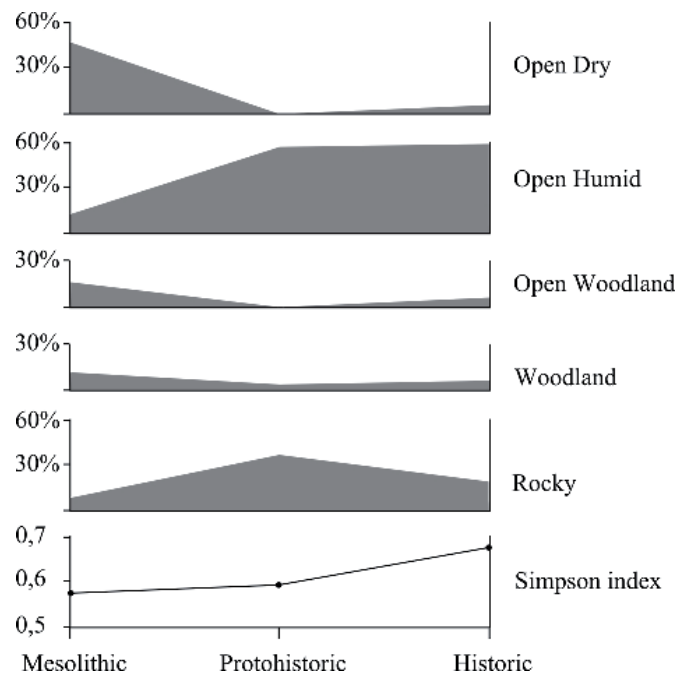
VF/1 III macro-units	Stratigraphical Units
Mesolithic	10, 20, 21, 30, 32
Protohistoric	19, 26, 27, 34, 35
Historic	1b, 2, 11, 12, 13, 16, 25, 101

**Tab. 2** - Number of Individuals (N.I.) of the three macro-units of Mondeval de Sora, sector VF1/III. / Numero degli Individui (N.I.) per le tre macro-unità di Mondeval de Sora, settore VF1/III.

	VF/1 III macro-units		
	Mesolithic	Protohistoric	Historic
<i>Apodemus cf. flavicollis</i>	1		
<i>Apodemus cf. sylvaticus</i>			1
<i>Apodemus sp.</i>			1
<i>M. (T.) gr. multiplex-subterraneus</i>	4	13	38
<i>Microtus arvalis</i>	29		6
<i>Microtus agrestis</i>		1	
<i>Chionomys nivalis</i>	4	9	14
<i>Clethrionomys glareolus</i>	3	1	3
<i>Dryomys nitedula</i>			1
<i>Muscardinus avellanarius</i>	1		
<i>Sciurus vulgaris</i>	1		
<i>Talpa caeca</i>			2
<i>Talpa cf. caeca</i>			1
<i>Talpa europaea</i>			1
<i>Talpa cf. europaea</i>			1
<i>Talpa sp.</i>			1
<i>Sorex cf. alpinus</i>			1
<i>Sorex gr. araneus</i>	3	1	6
<b>Total N.I.</b>	<b>46</b>	<b>25</b>	<b>77</b>



**Fig. 2** - General selection of the small mammals from VF1/III site. 1: *Microtus arvalis*, right M1; 2: *M. (T.) gr. multiplex-subterraneus*, right M1; 3: *Clethrionomys glareolus*, right M1; 4: *Chionomys nivalis*, left M1; 5: *Apodemus cf. sylvaticus*, right M1-2; 6: *Sciurus vulgaris*, left M2; 7: *Sorex gr. araneus*, right mandible. / Micromammiferi da VF1/III (selezione generale). 1: *Microtus arvalis*, M1 dx; 2: *M. (T.) gr. multiplex-subterraneus*, M1 dx; 3: *Clethrionomys glareolus*, M1 dx; 4: *Chionomys nivalis*, M1 sx; 5: *Apodemus cf. sylvaticus*, M1-2 dx; 6: *Sciurus vulgaris*, M2 sx; 7: *Sorex gr. araneus*, mandibola dx.



**Fig. 3** - Habitat Weighting and Simpson index of Mondeval de Sora VF1/III. / Habitat Weighting e indice di Simpson di Mondeval de Sora VF1/III.

dently related to the general redistribution of biodiversity and faunal change that affects the final moments of Late Pleistocene and the Holocene, especially in northern Italy (Berto 2013).

## Conclusions

The small mammals assemblage from Mondeval de Sora represents a unique assemblage in a unique setting reflecting environmental changes from early to late Holocene at a high altitude context. Despite the relative low N.I. there is clear evidence for landscape changes from an open grassland with woodlands extending over the present tree line in the Mesolithic to the Proto-historic and Historic environment which appears very similar to the one that characterizes Val Fiorentina today.

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